FIG.1

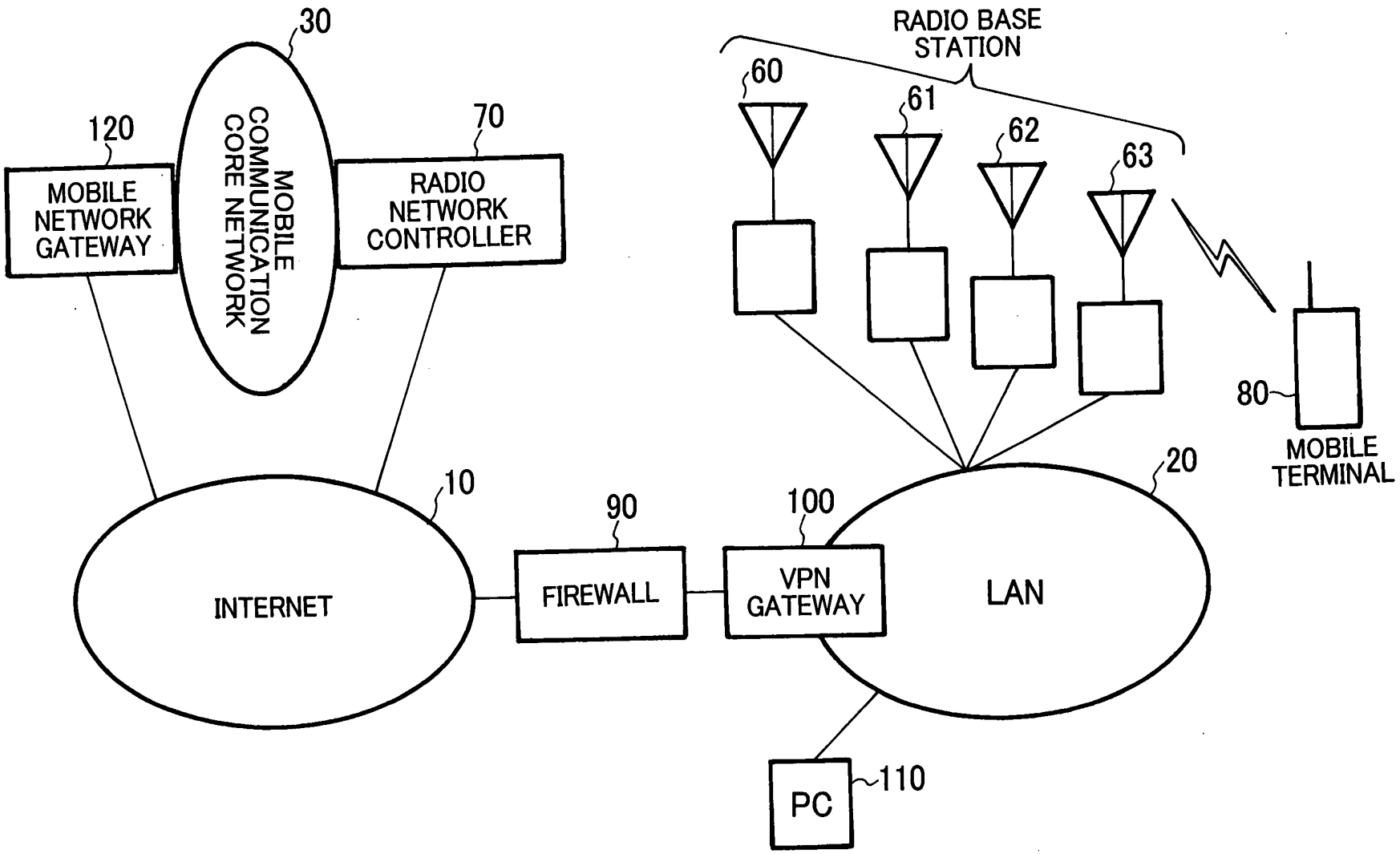

30
MOBILE COMMUNICATION CORE NETWORK
120
MOBILE NETWORK GATEWAY
70
RADIO NETWORK CONTROLLER
RADIO BASE STATION
60
61
62
63
80
MOBILE TERMINAL
10
INTERNET
90
FIREWALL
100
VPN GATEWAY
20
LAN
PC
110

FIG.2

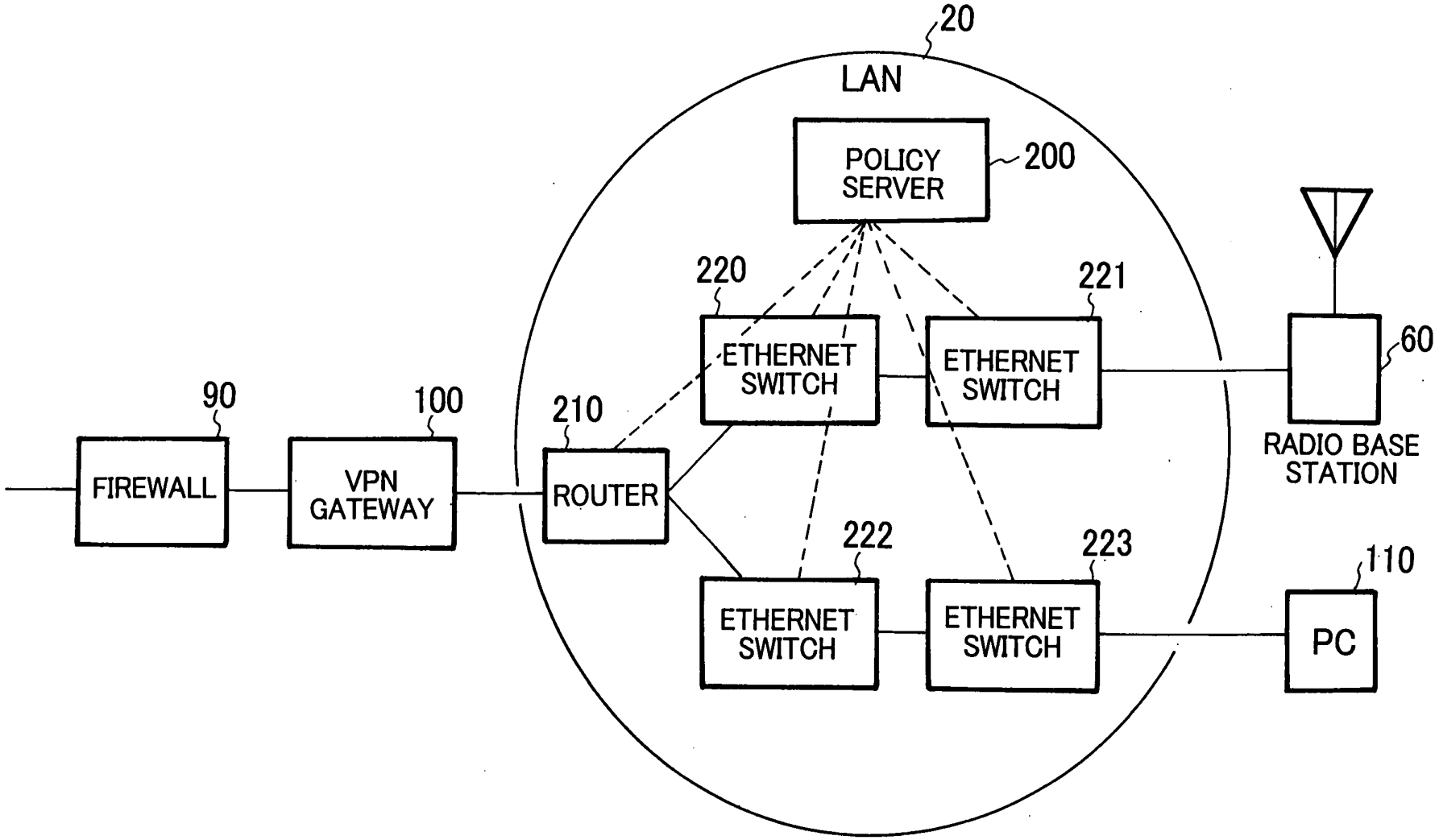

20
LAN
POLICY SERVER
200
220
221
ETHERNET SWITCH
ETHERNET SWITCH
60
RADIO BASE STATION
90
100
210
FIREWALL
VPN GATEWAY
ROUTER
222
223
ETHERNET SWITCH
ETHERNET SWITCH
110
PC

FIG.3

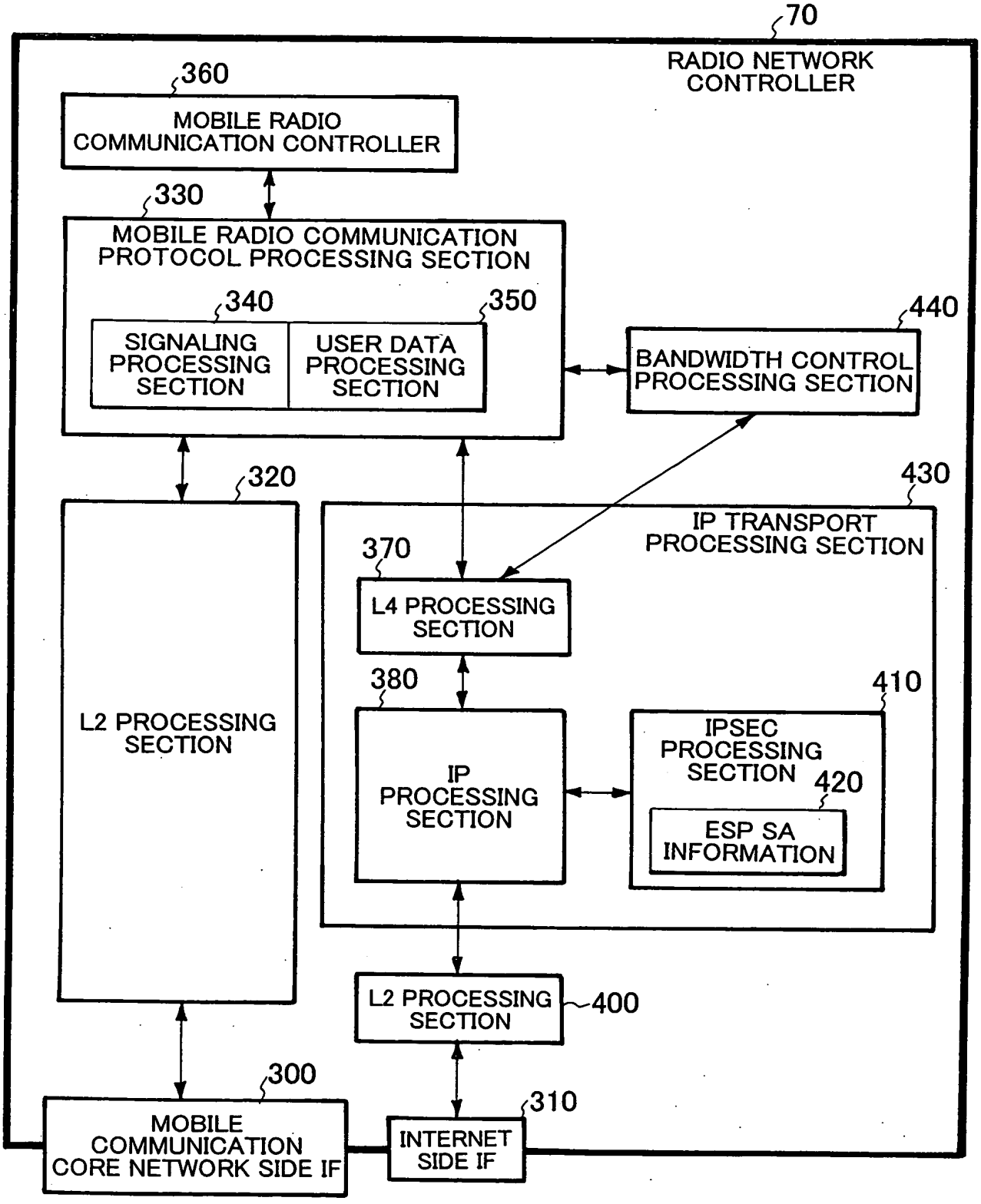

70
RADIO NETWORK CONTROLLER
360
MOBILE RADIO COMMUNICATION CONTROLLER
330
MOBILE RADIO COMMUNICATION PROTOCOL PROCESSING SECTION
340
SIGNALING PROCESSING SECTION
350
USER DATA PROCESSING SECTION
440
BANDWIDTH CONTROL PROCESSING SECTION
320
L2 PROCESSING SECTION
430
IP TRANSPORT PROCESSING SECTION
370
L4 PROCESSING SECTION
380
IP PROCESSING SECTION
410
IPSEC PROCESSING SECTION
420
ESP SA INFORMATION
L2 PROCESSING SECTION
400
300
MOBILE COMMUNICATION CORE NETWORK SIDE IF
310
INTERNET SIDE IF

FIG.4

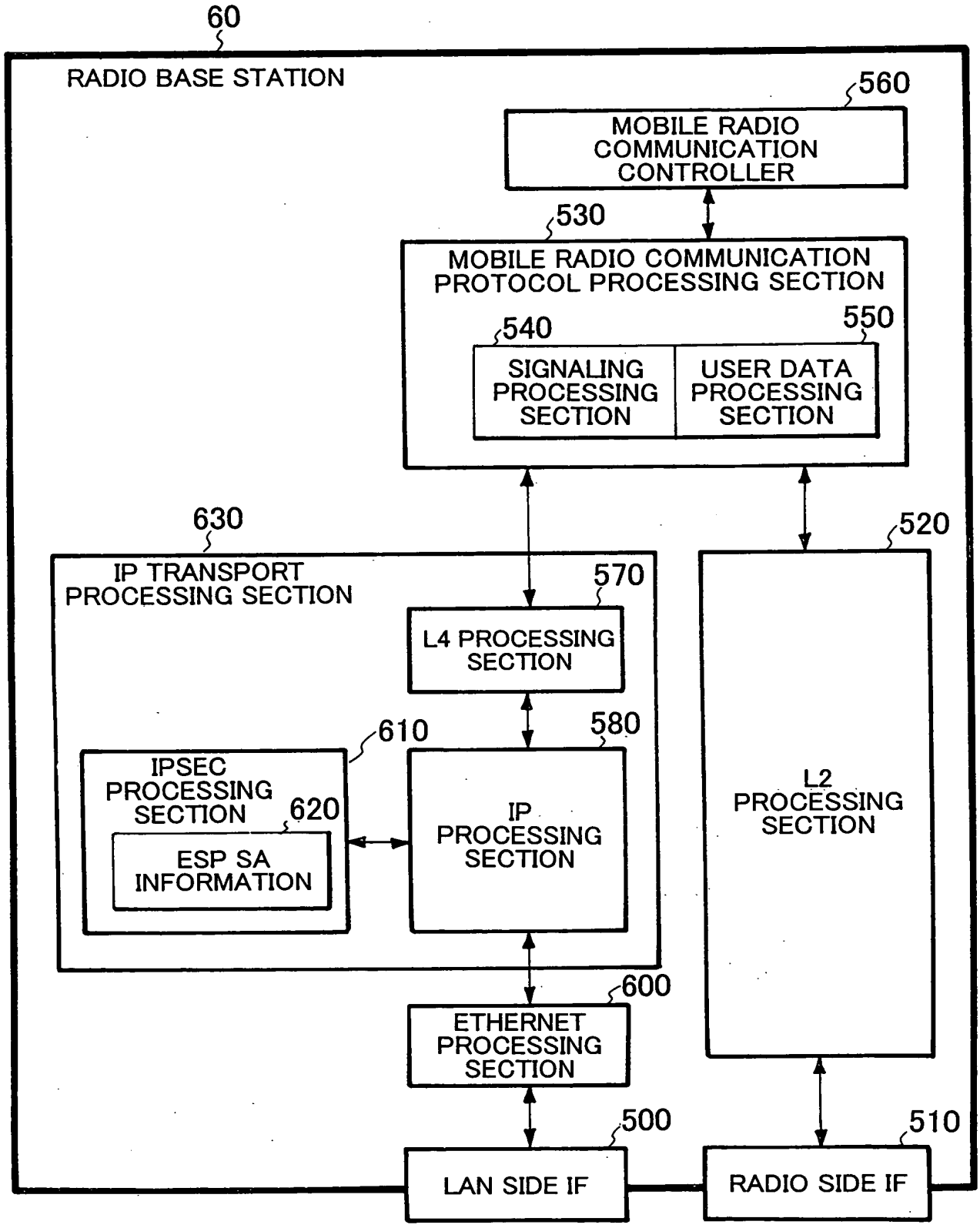

60
RADIO BASE STATION
560
MOBILE RADIO COMMUNICATION CONTROLLER
530
MOBILE RADIO COMMUNICATION PROTOCOL PROCESSING SECTION
540
SIGNALING PROCESSING SECTION
550
USER DATA PROCESSING SECTION
630
IP TRANSPORT PROCESSING SECTION
570
L4 PROCESSING SECTION
610
IPSEC PROCESSING SECTION
620
ESP SA INFORMATION
580
IP PROCESSING SECTION
520
L2 PROCESSING SECTION
600
ETHERNET PROCESSING SECTION
500
LAN SIDE IF
510
RADIO SIDE IF

FIG.5

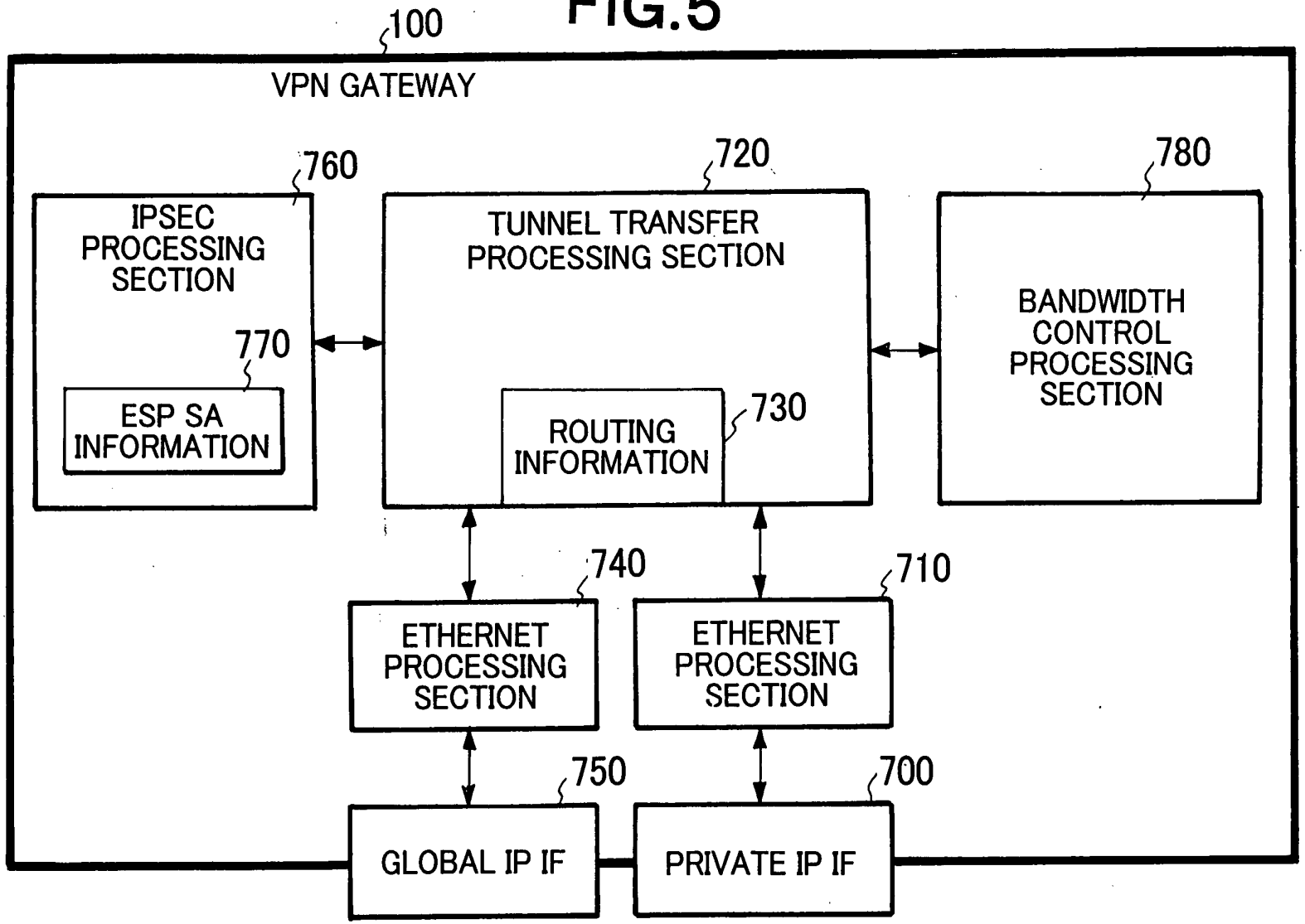

100
VPN GATEWAY
760
IPSEC PROCESSING SECTION
770
ESP SA INFORMATION
720
TUNNEL TRANSFER PROCESSING SECTION
ROUTING INFORMATION
730
780
BANDWIDTH CONTROL PROCESSING SECTION
740
ETHERNET PROCESSING SECTION
710
ETHERNET PROCESSING SECTION
750
GLOBAL IP IF
700
PRIVATE IP IF

FIG.6

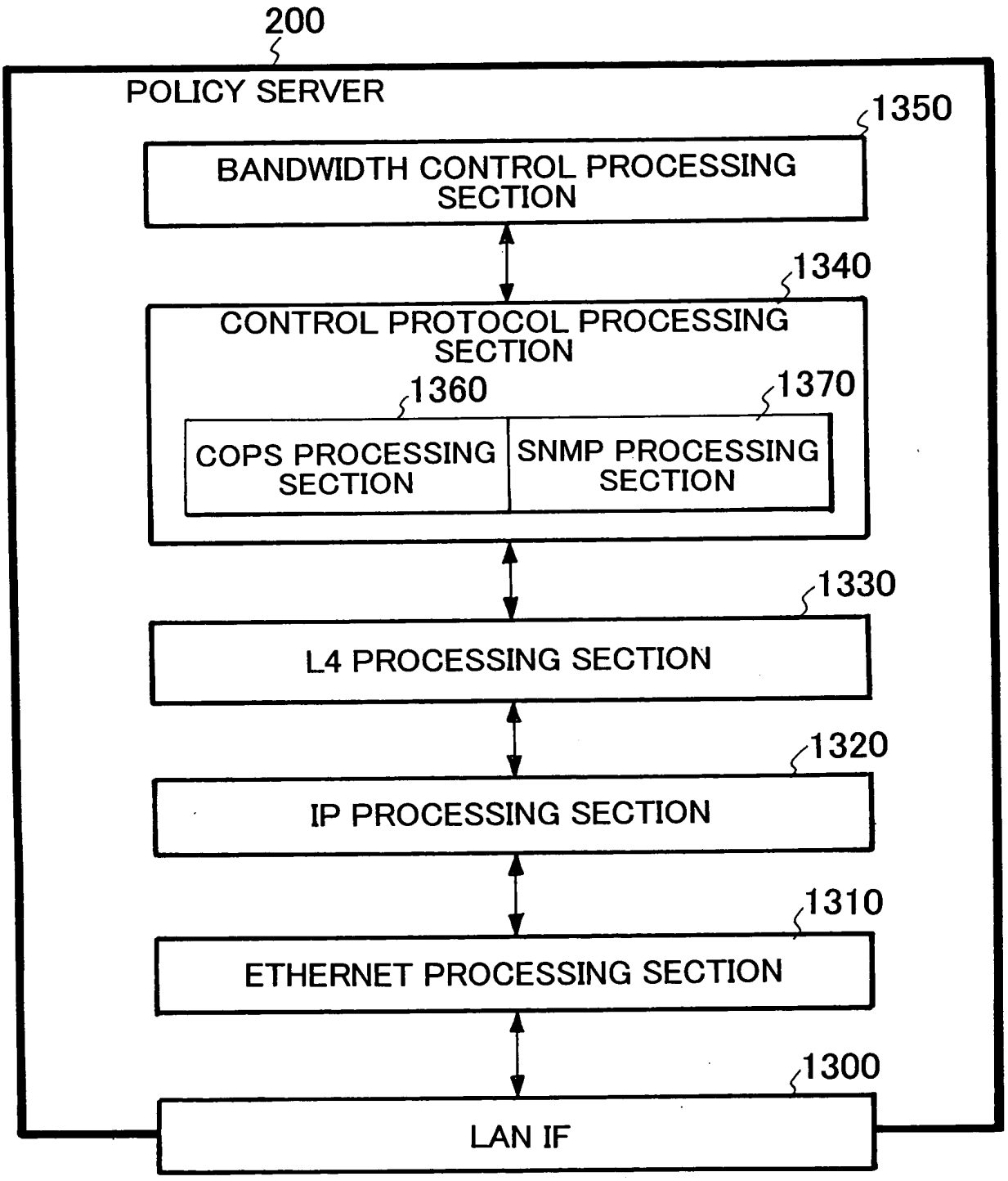

200
POLICY SERVER
1350
BANDWIDTH CONTROL PROCESSING SECTION
1340
CONTROL PROTOCOL PROCESSING SECTION
1360
COPS PROCESSING SECTION
1370
SNMP PROCESSING SECTION
1330
L4 PROCESSING SECTION
1320
IP PROCESSING SECTION
1310
ETHERNET PROCESSING SECTION
1300
LAN IF

FIG.7A

PACKET FORMAT EXCHANGED BETWEEN
RADIO BASE STATION AND VPN GATEWAY

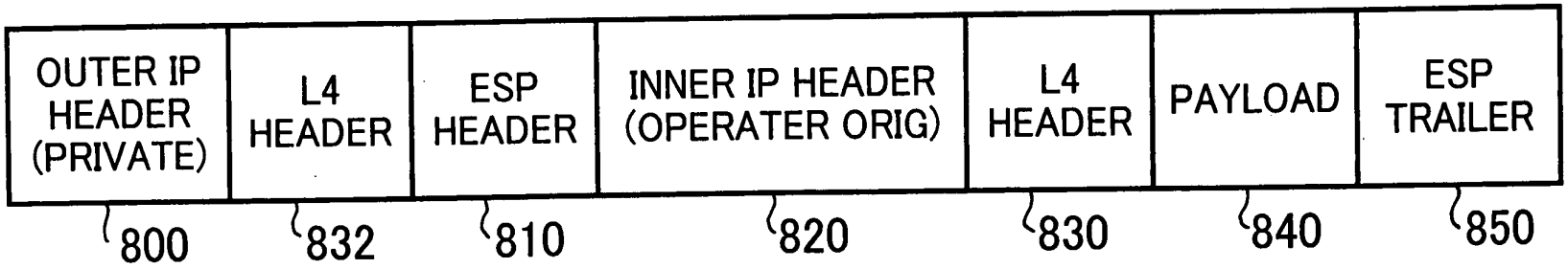


FIG.7B

PACKET FORMAT EXCHANGED BETWEEN
VPN GATEWAY AND RADIO NETWORK CONTROLLER

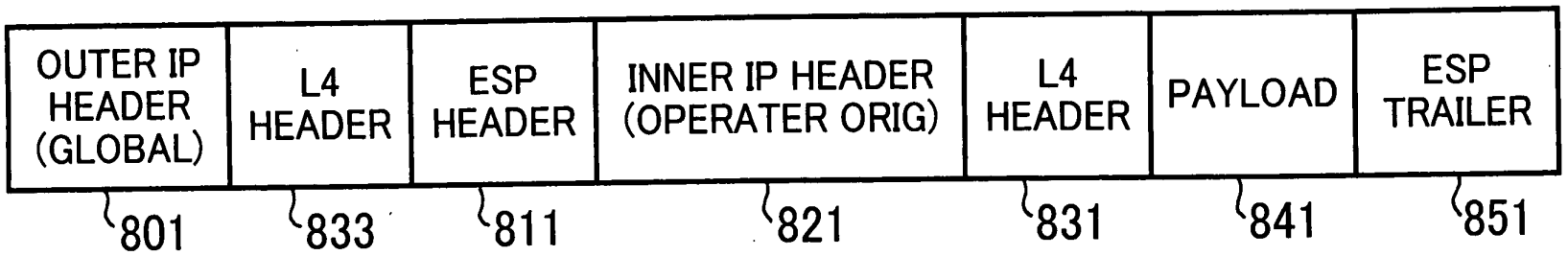


FIG.8

900: TRANSFER TABLE

RADIO NETWORK CONTROLLER		RADIO BASE STATION	
GLOBAL ADDRESS	OPERATOR'S UNIQUE ADDRESS	PRIVATE ADDRESS	OPERATOR'S UNIQUE ADDRESS
aaa.bbb.ccc.ddd	mmm.nnn.ooo.ppp	eee.fff.ggg.hhh	mmm.nnn.ooo.qqq
		eee.fff.ggg.kkk	mmm.nnn.ooo.rrr
		eee.fff.zzz.yyy	mmm.nnn.ooo.sss
		eee.fff.zzz.xxx	mmm.nnn.ooo.ttt

FIG.9

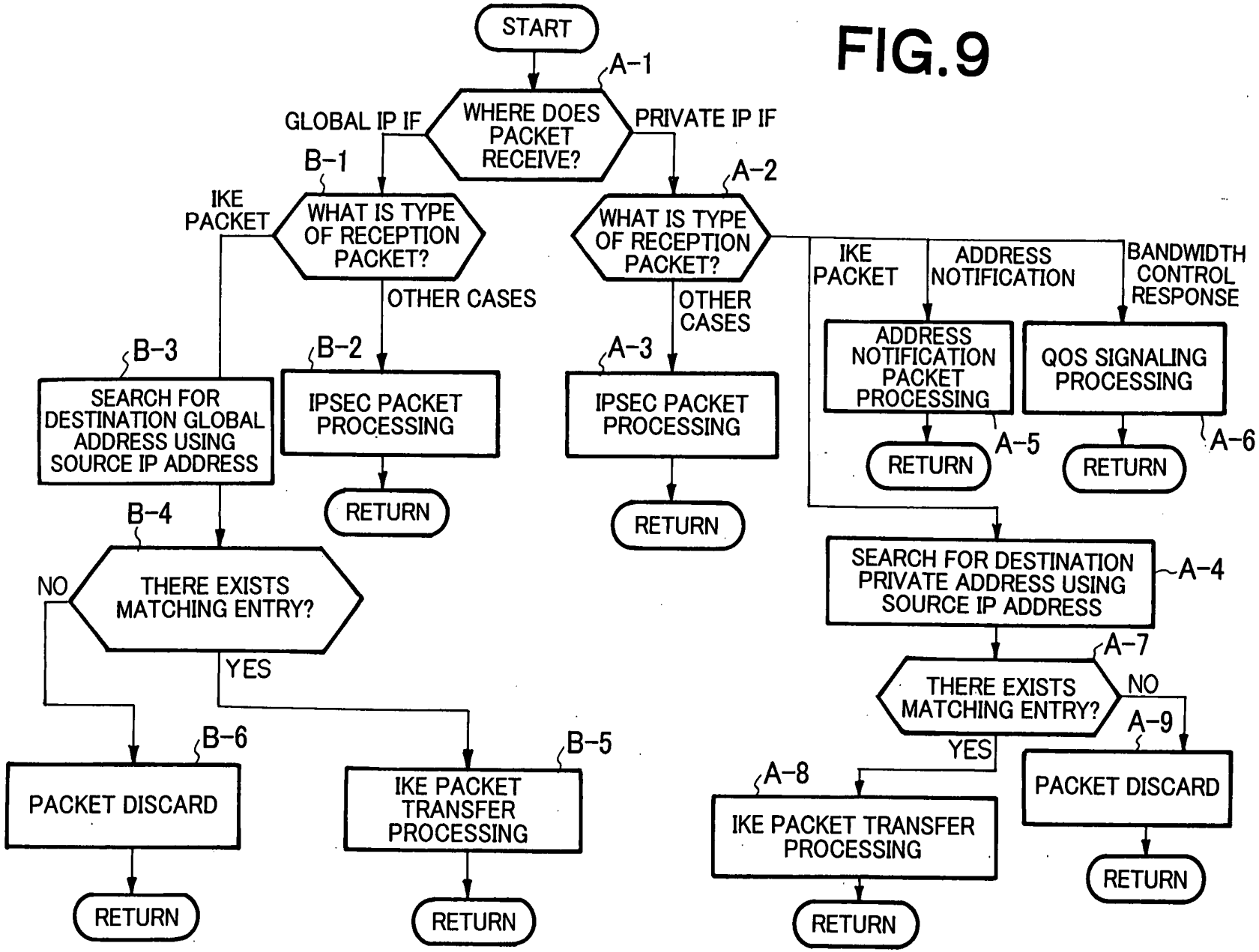

START
A-1
WHERE DOES PACKET RECEIVE?
GLOBAL IP IF
PRIVATE IP IF
B-1
WHAT IS TYPE OF RECEPTION PACKET?
IKE PACKET
OTHER CASES
A-2
WHAT IS TYPE OF RECEPTION PACKET?
IKE PACKET
ADDRESS NOTIFICATION
BANDWIDTH CONTROL RESPONSE
OTHER CASES
B-3
SEARCH FOR DESTINATION GLOBAL ADDRESS USING SOURCE IP ADDRESS
B-2
IPSEC PACKET PROCESSING
RETURN
A-3
IPSEC PACKET PROCESSING
RETURN
ADDRESS NOTIFICATION PACKET PROCESSING
A-5
RETURN
QOS SIGNALING PROCESSING
A-6
RETURN
B-4
NO
THERE EXISTS MATCHING ENTRY?
YES
SEARCH FOR DESTINATION PRIVATE ADDRESS USING SOURCE IP ADDRESS
A-4
A-7
THERE EXISTS MATCHING ENTRY?
NO
A-9
YES
B-6
PACKET DISCARD
RETURN
B-5
IKE PACKET TRANSFER PROCESSING
RETURN
A-8
IKE PACKET TRANSFER PROCESSING
RETURN
PACKET DISCARD
RETURN

FIG. 10

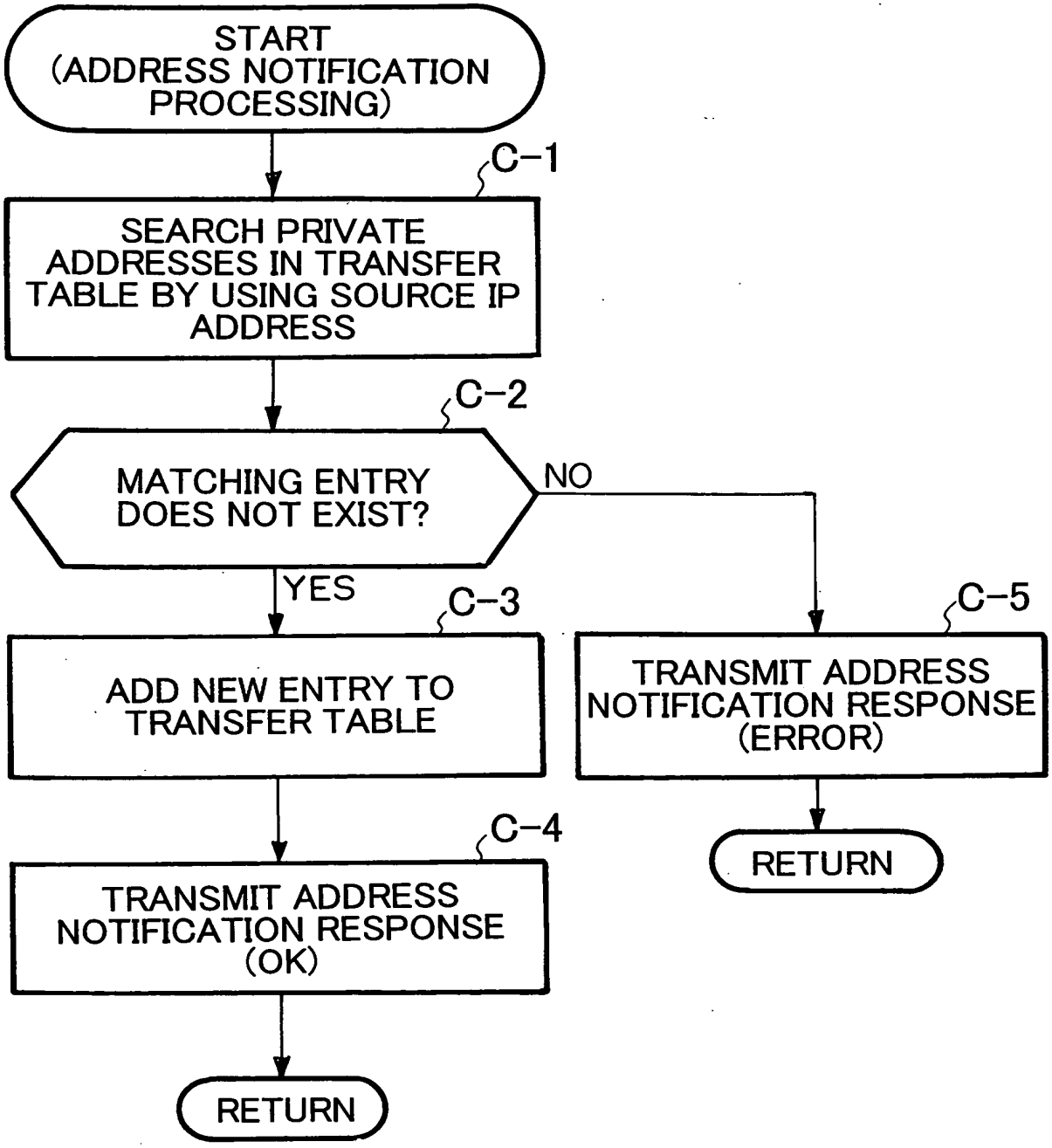

START
(ADDRESS NOTIFICATION PROCESSING)
C-1
SEARCH PRIVATE ADDRESSES IN TRANSFER TABLE BY USING SOURCE IP ADDRESS
C-2
MATCHING ENTRY DOES NOT EXIST?
NO
YES
C-3
ADD NEW ENTRY TO TRANSFER TABLE
C-4
TRANSMIT ADDRESS NOTIFICATION RESPONSE (OK)
RETURN
C-5
TRANSMIT ADDRESS NOTIFICATION RESPONSE (ERROR)
RETURN

FIG.11

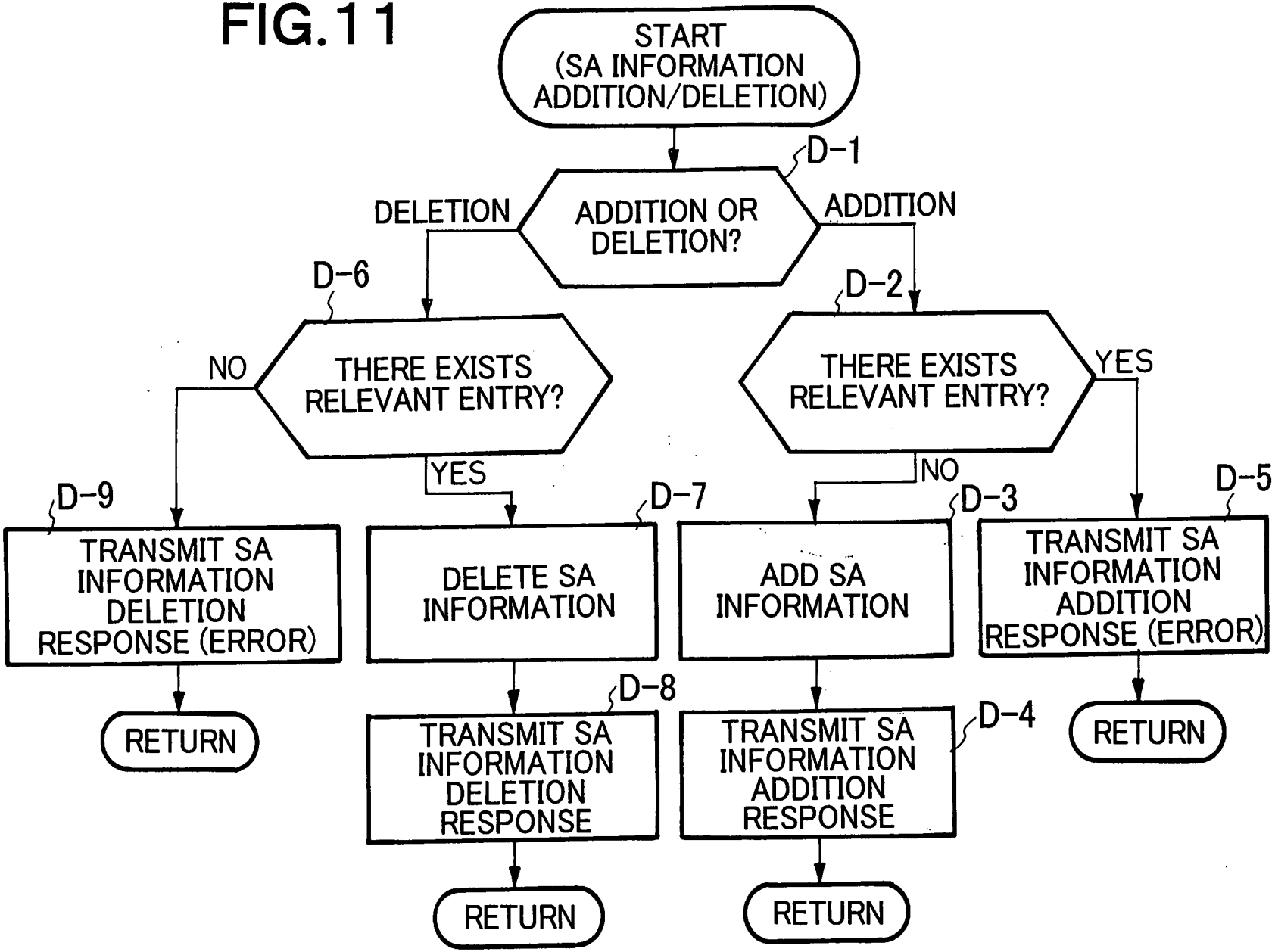

START
(SA INFORMATION
ADDITION/DELETION)
D-1
ADDITION OR
DELETION?
DELETION
ADDITION
D-6
THERE EXISTS
RELEVANT ENTRY?
NO
YES
D-2
THERE EXISTS
RELEVANT ENTRY?
YES
NO
D-9
TRANSMIT SA
INFORMATION
DELETION
RESPONSE (ERROR)
D-7
DELETE SA
INFORMATION
D-3
ADD SA
INFORMATION
D-5
TRANSMIT SA
INFORMATION
ADDITION
RESPONSE (ERROR)
RETURN
D-8
TRANSMIT SA
INFORMATION
DELETION
RESPONSE
D-4
TRANSMIT SA
INFORMATION
ADDITION
RESPONSE
RETURN
RETURN
RETURN

FIG. 12

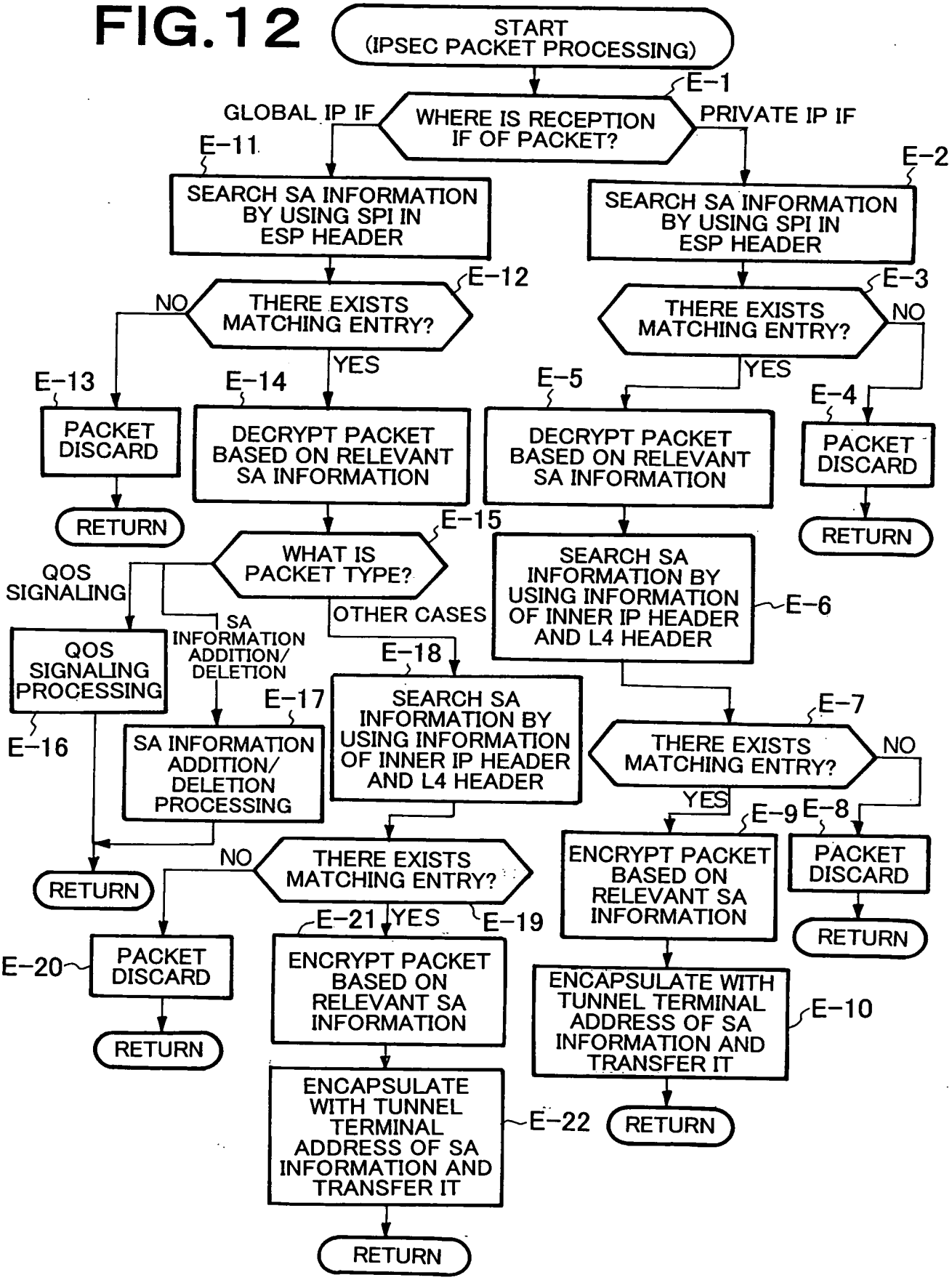

START (IPSEC PACKET PROCESSING)
E-1
WHERE IS RECEPTION IF OF PACKET?
GLOBAL IP IF
PRIVATE IP IF
E-11
SEARCH SA INFORMATION BY USING SPI IN ESP HEADER
E-2
SEARCH SA INFORMATION BY USING SPI IN ESP HEADER
E-12
THERE EXISTS MATCHING ENTRY?
NO
YES
E-3
THERE EXISTS MATCHING ENTRY?
NO
YES
E-13
PACKET DISCARD
RETURN
E-14
DECRYPT PACKET BASED ON RELEVANT SA INFORMATION
E-5
DECRYPT PACKET BASED ON RELEVANT SA INFORMATION
E-4
PACKET DISCARD
RETURN
E-15
WHAT IS PACKET TYPE?
QOS SIGNALING
SA INFORMATION ADDITION/ DELETION
OTHER CASES
QOS SIGNALING PROCESSING
E-16
E-17
SA INFORMATION ADDITION/ DELETION PROCESSING
E-18
SEARCH SA INFORMATION BY USING INFORMATION OF INNER IP HEADER AND L4 HEADER
SEARCH SA INFORMATION BY USING INFORMATION OF INNER IP HEADER AND L4 HEADER
E-6
E-7
THERE EXISTS MATCHING ENTRY?
NO
YES
E-9
ENCRYPT PACKET BASED ON RELEVANT SA INFORMATION
E-8
PACKET DISCARD
RETURN
RETURN
NO
THERE EXISTS MATCHING ENTRY?
E-21
YES
E-19
E-20
PACKET DISCARD
RETURN
ENCRYPT PACKET BASED ON RELEVANT SA INFORMATION
ENCAPSULATE WITH TUNNEL TERMINAL ADDRESS OF SA INFORMATION AND TRANSFER IT
E-10
ENCAPSULATE WITH TUNNEL TERMINAL ADDRESS OF SA INFORMATION AND TRANSFER IT
E-22
RETURN
RETURN

FIG.13

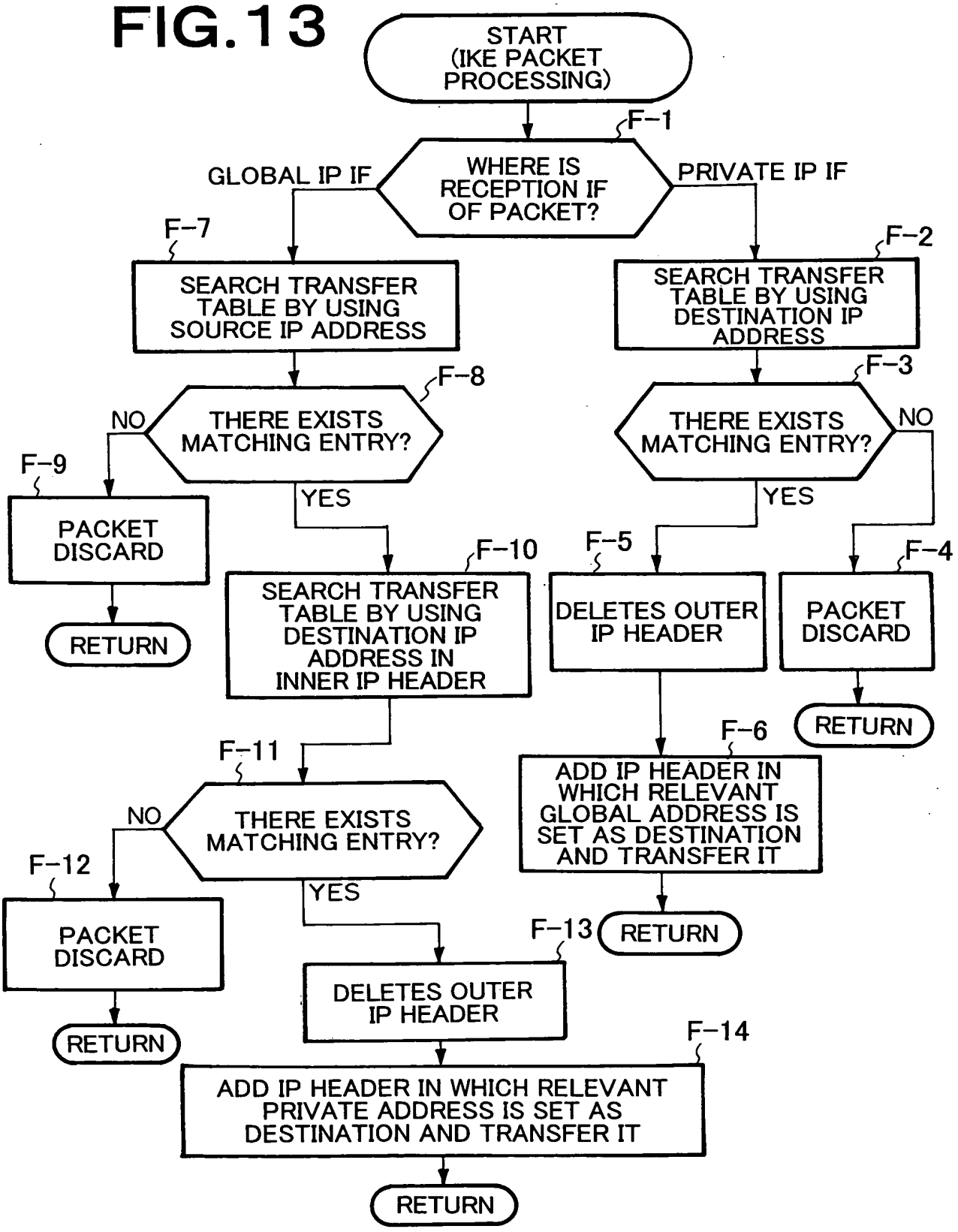

START
(IKE PACKET
PROCESSING)
F-1
WHERE IS
RECEPTION IF
OF PACKET?
GLOBAL IP IF
PRIVATE IP IF
F-7
SEARCH TRANSFER
TABLE BY USING
SOURCE IP ADDRESS
F-2
SEARCH TRANSFER
TABLE BY USING
DESTINATION IP
ADDRESS
F-8
THERE EXISTS
MATCHING ENTRY?
NO
YES
F-3
THERE EXISTS
MATCHING ENTRY?
NO
YES
F-9
PACKET
DISCARD
RETURN
F-10
SEARCH TRANSFER
TABLE BY USING
DESTINATION IP
ADDRESS IN
INNER IP HEADER
F-5
DELETES OUTER
IP HEADER
F-4
PACKET
DISCARD
RETURN
F-6
ADD IP HEADER IN
WHICH RELEVANT
GLOBAL ADDRESS IS
SET AS DESTINATION
AND TRANSFER IT
RETURN
F-11
THERE EXISTS
MATCHING ENTRY?
NO
YES
F-12
PACKET
DISCARD
RETURN
F-13
DELETES OUTER
IP HEADER
F-14
ADD IP HEADER IN WHICH RELEVANT
PRIVATE ADDRESS IS SET AS
DESTINATION AND TRANSFER IT
RETURN

FIG.14

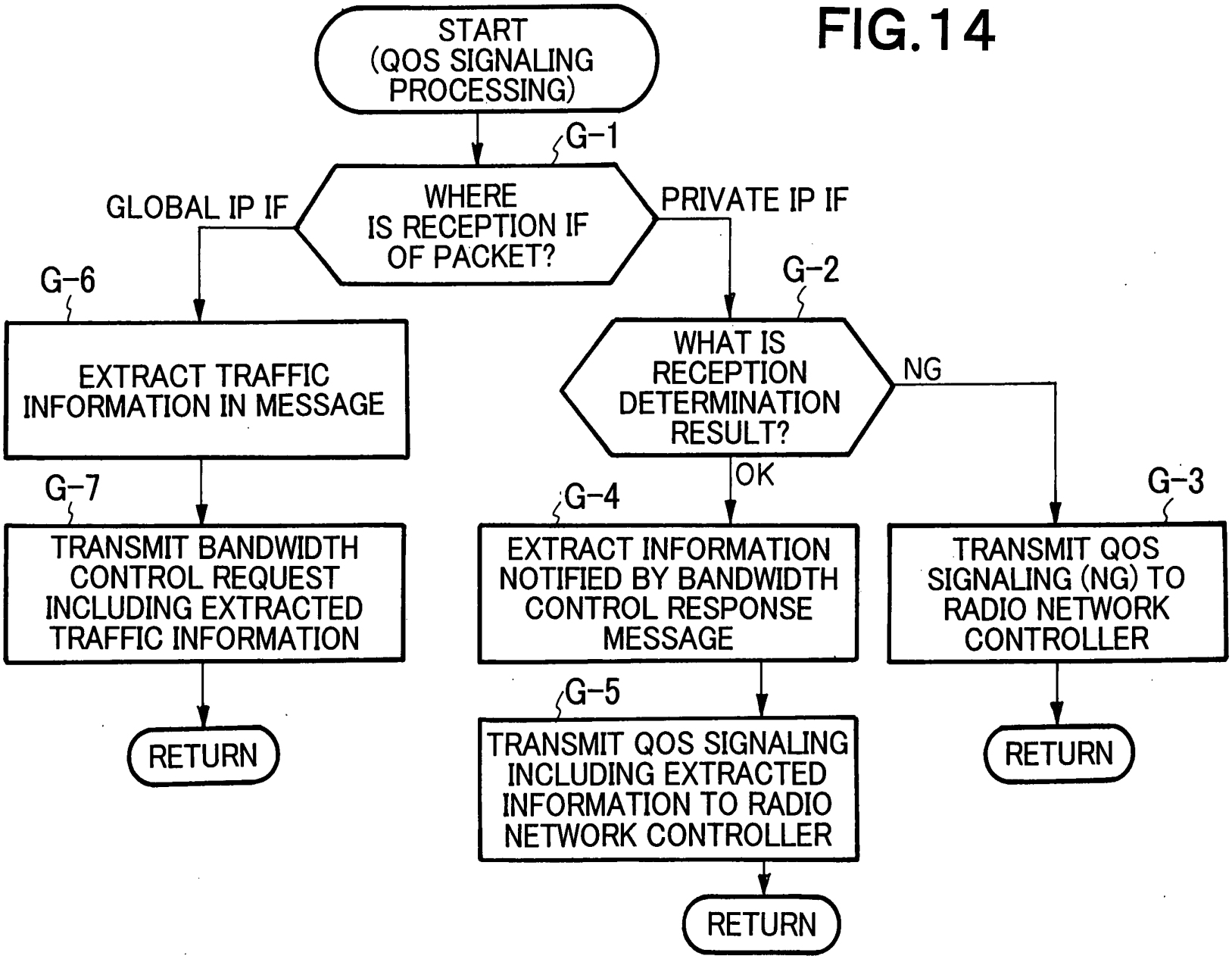

START
(QOS SIGNALING
PROCESSING)
G-1
WHERE
IS RECEPTION IF
OF PACKET?
GLOBAL IP IF
PRIVATE IP IF
G-6
EXTRACT TRAFFIC
INFORMATION IN MESSAGE
G-7
TRANSMIT BANDWIDTH
CONTROL REQUEST
INCLUDING EXTRACTED
TRAFFIC INFORMATION
RETURN
G-2
WHAT IS
RECEPTION
DETERMINATION
RESULT?
NG
OK
G-4
EXTRACT INFORMATION
NOTIFIED BY BANDWIDTH
CONTROL RESPONSE
MESSAGE
G-5
TRANSMIT QOS SIGNALING
INCLUDING EXTRACTED
INFORMATION TO RADIO
NETWORK CONTROLLER
RETURN
G-3
TRANSMIT QOS
SIGNALING (NG) TO
RADIO NETWORK
CONTROLLER
RETURN

FIG.15

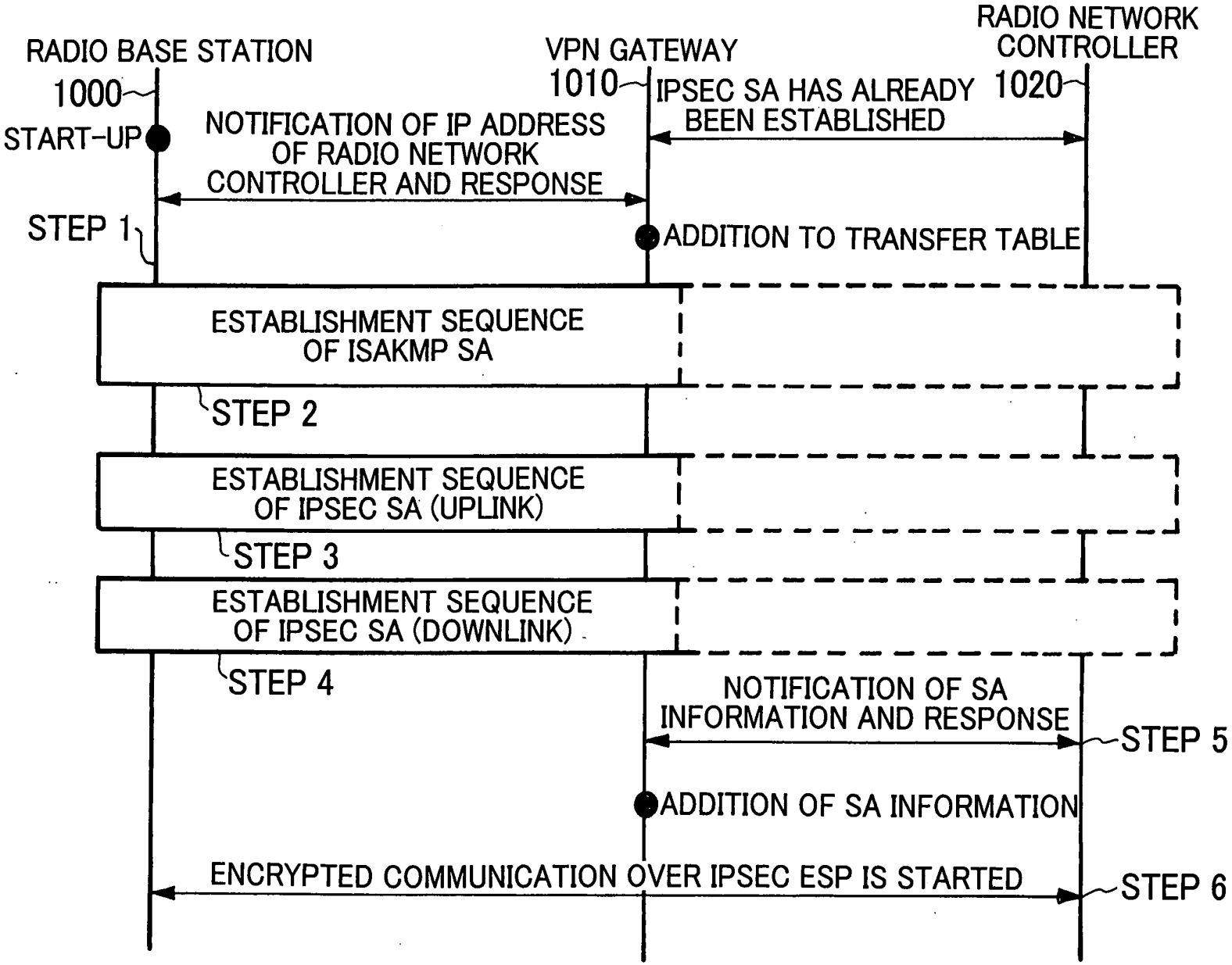

RADIO BASE STATION
1000
VPN GATEWAY
1010
RADIO NETWORK CONTROLLER
1020
START-UP
NOTIFICATION OF IP ADDRESS OF RADIO NETWORK CONTROLLER AND RESPONSE
IPSEC SA HAS ALREADY BEEN ESTABLISHED
STEP 1
ADDITION TO TRANSFER TABLE
ESTABLISHMENT SEQUENCE OF ISAKMP SA
STEP 2
ESTABLISHMENT SEQUENCE OF IPSEC SA (UPLINK)
STEP 3
ESTABLISHMENT SEQUENCE OF IPSEC SA (DOWNLINK)
STEP 4
NOTIFICATION OF SA INFORMATION AND RESPONSE
STEP 5
ADDITION OF SA INFORMATION
ENCRYPTED COMMUNICATION OVER IPSEC ESP IS STARTED
STEP 6

FIG.16

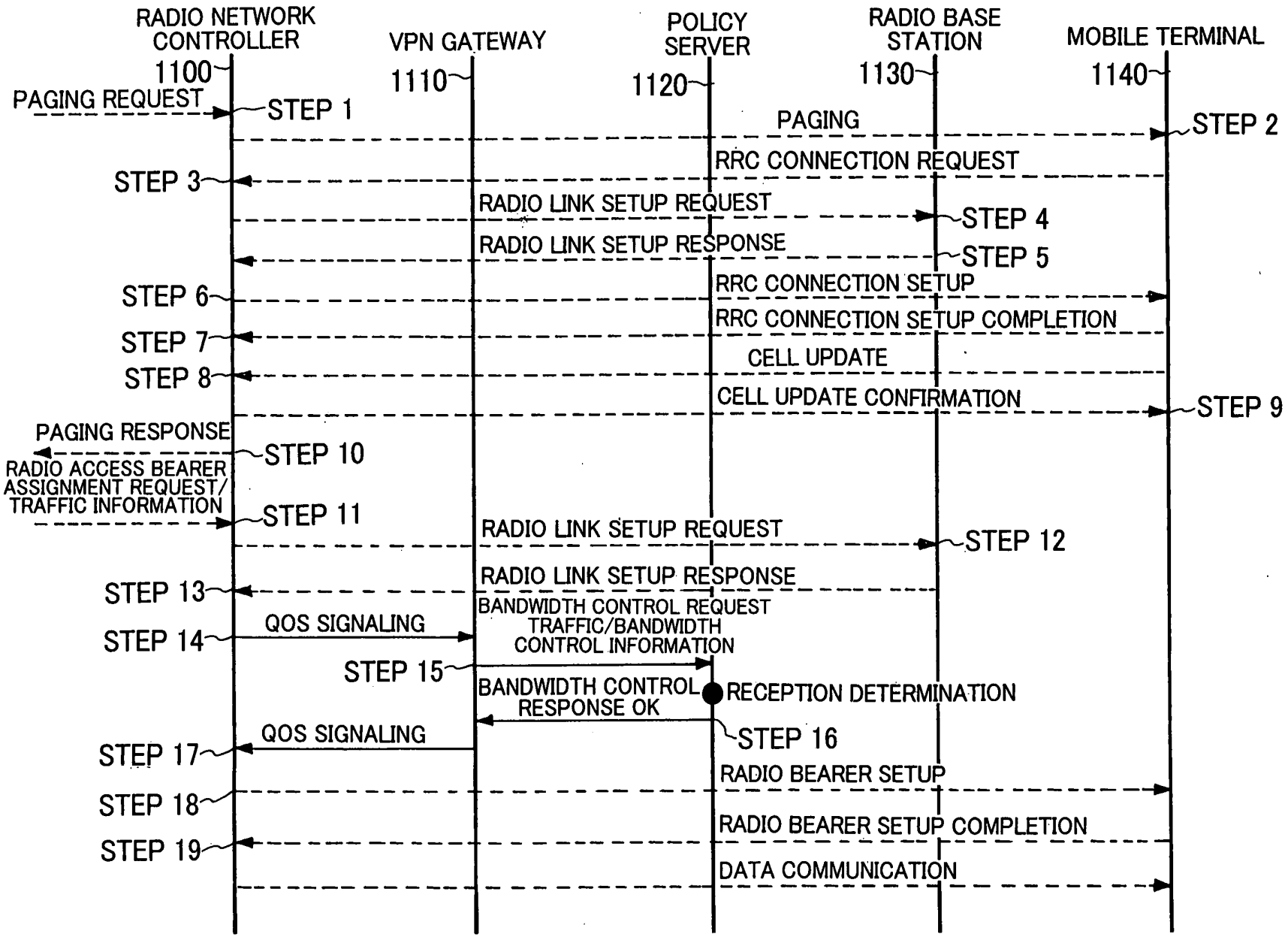

RADIO NETWORK CONTROLLER
1100
VPN GATEWAY
1110
POLICY SERVER
1120
RADIO BASE STATION
1130
MOBILE TERMINAL
1140
PAGING REQUEST
STEP 1
PAGING
STEP 2
RRC CONNECTION REQUEST
STEP 3
RADIO LINK SETUP REQUEST
STEP 4
RADIO LINK SETUP RESPONSE
STEP 5
RRC CONNECTION SETUP
STEP 6
RRC CONNECTION SETUP COMPLETION
STEP 7
CELL UPDATE
STEP 8
CELL UPDATE CONFIRMATION
STEP 9
PAGING RESPONSE
STEP 10
RADIO ACCESS BEARER ASSIGNMENT REQUEST/ TRAFFIC INFORMATION
STEP 11
RADIO LINK SETUP REQUEST
STEP 12
RADIO LINK SETUP RESPONSE
STEP 13
BANDWIDTH CONTROL REQUEST TRAFFIC/BANDWIDTH CONTROL INFORMATION
QOS SIGNALING
STEP 14
STEP 15
BANDWIDTH CONTROL RESPONSE OK
RECEPTION DETERMINATION
STEP 16
QOS SIGNALING
STEP 17
RADIO BEARER SETUP
STEP 18
RADIO BEARER SETUP COMPLETION
STEP 19
DATA COMMUNICATION

FIG.17

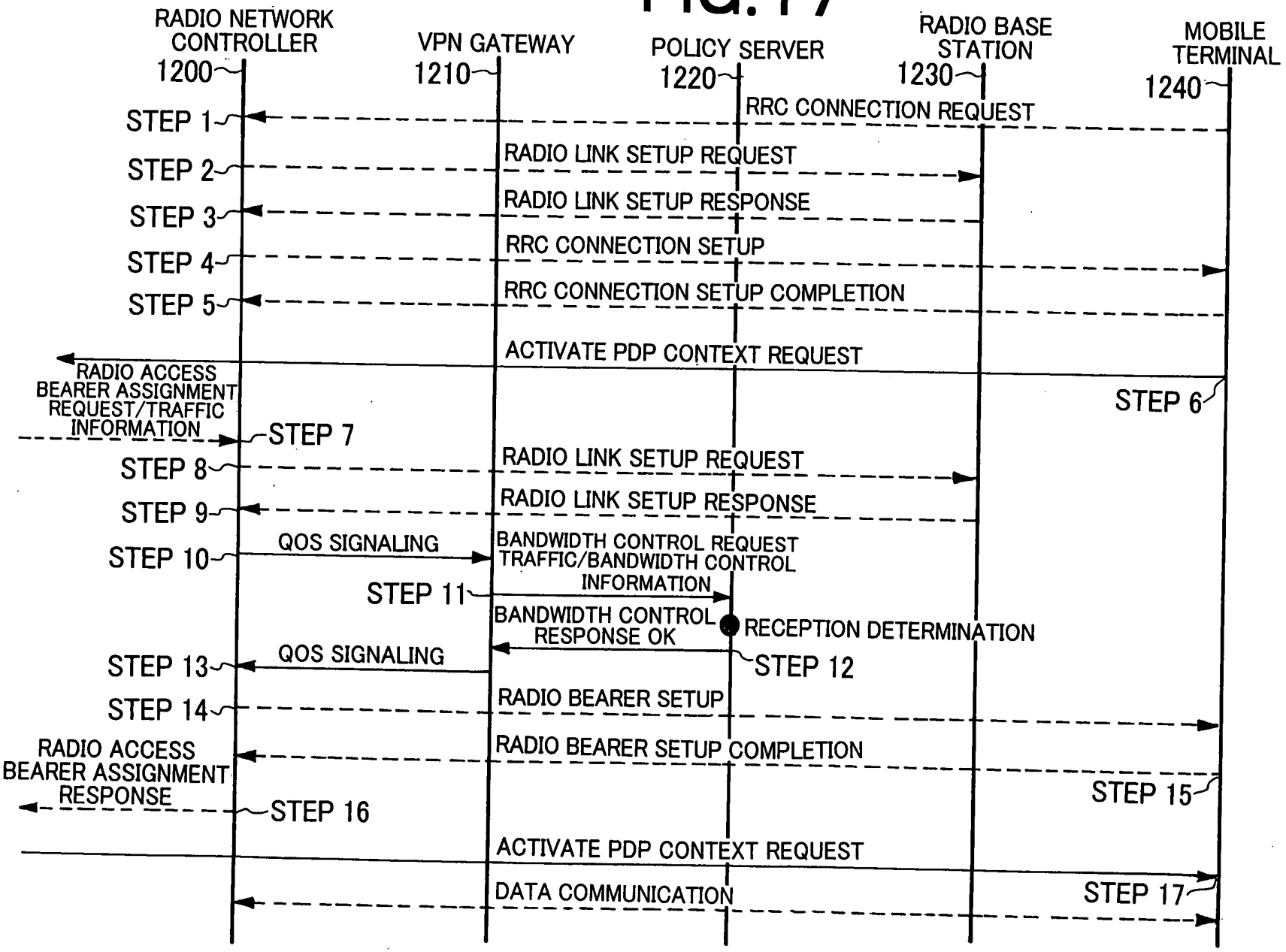

RADIO NETWORK CONTROLLER
1200
VPN GATEWAY
1210
POLICY SERVER
1220
RADIO BASE STATION
1230
MOBILE TERMINAL
1240
STEP 1
RRC CONNECTION REQUEST
STEP 2
RADIO LINK SETUP REQUEST
STEP 3
RADIO LINK SETUP RESPONSE
STEP 4
RRC CONNECTION SETUP
STEP 5
RRC CONNECTION SETUP COMPLETION
ACTIVATE PDP CONTEXT REQUEST
STEP 6
RADIO ACCESS BEARER ASSIGNMENT REQUEST/TRAFFIC INFORMATION
STEP 7
STEP 8
RADIO LINK SETUP REQUEST
STEP 9
RADIO LINK SETUP RESPONSE
STEP 10
QOS SIGNALING
BANDWIDTH CONTROL REQUEST TRAFFIC/BANDWIDTH CONTROL INFORMATION
STEP 11
BANDWIDTH CONTROL RESPONSE OK
RECEPTION DETERMINATION
STEP 12
STEP 13
QOS SIGNALING
STEP 14
RADIO BEARER SETUP
RADIO BEARER SETUP COMPLETION
STEP 15
RADIO ACCESS BEARER ASSIGNMENT RESPONSE
STEP 16
ACTIVATE PDP CONTEXT REQUEST
DATA COMMUNICATION
STEP 17

FIG.18

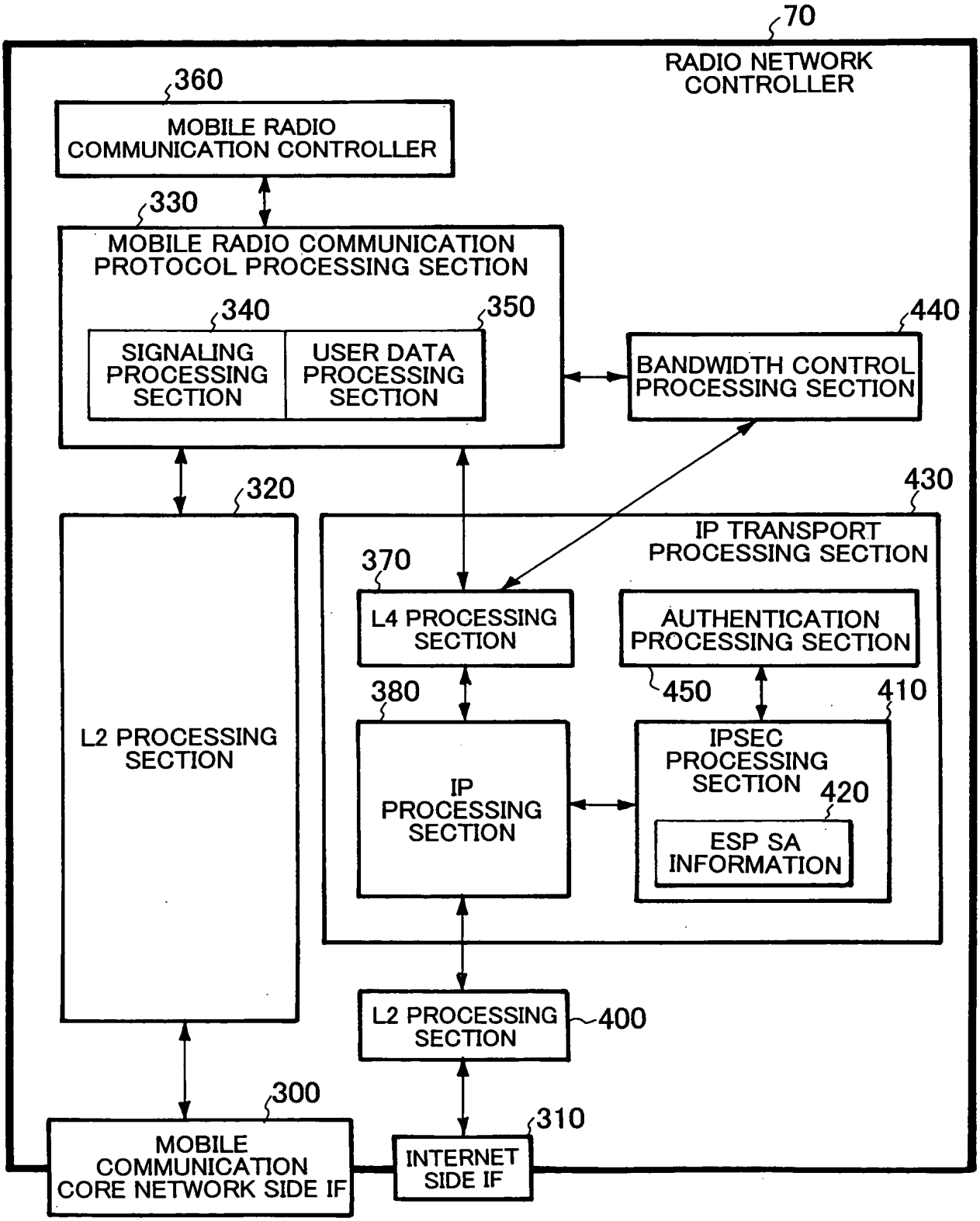

70
RADIO NETWORK CONTROLLER
360
MOBILE RADIO COMMUNICATION CONTROLLER
330
MOBILE RADIO COMMUNICATION PROTOCOL PROCESSING SECTION
340
SIGNALING PROCESSING SECTION
350
USER DATA PROCESSING SECTION
440
BANDWIDTH CONTROL PROCESSING SECTION
320
L2 PROCESSING SECTION
430
IP TRANSPORT PROCESSING SECTION
370
L4 PROCESSING SECTION
AUTHENTICATION PROCESSING SECTION
380
450
410
IP PROCESSING SECTION
IPSEC PROCESSING SECTION
420
ESP SA INFORMATION
L2 PROCESSING SECTION
400
300
310
MOBILE COMMUNICATION CORE NETWORK SIDE IF
INTERNET SIDE IF

FIG.19

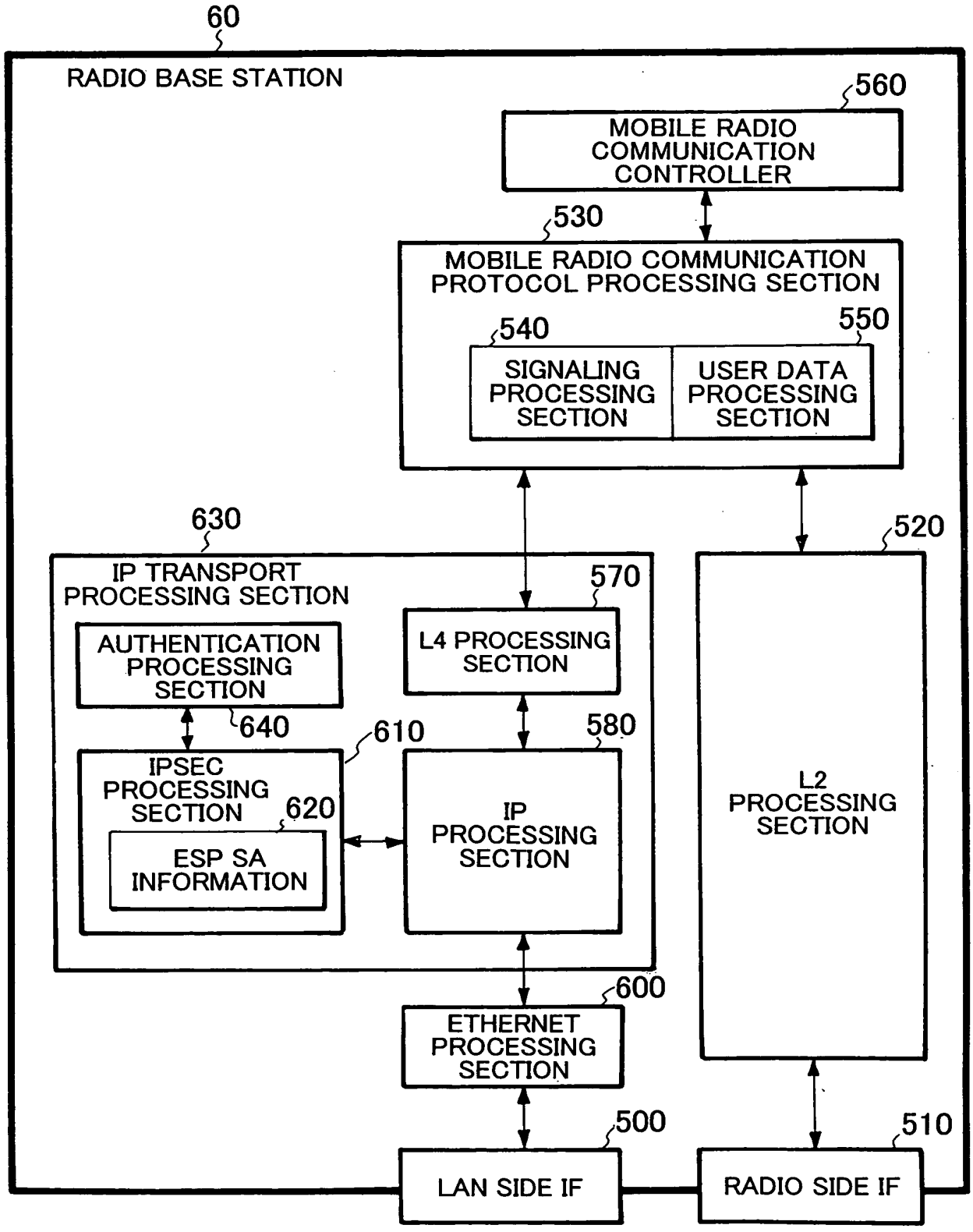

60
RADIO BASE STATION
560
MOBILE RADIO COMMUNICATION CONTROLLER
530
MOBILE RADIO COMMUNICATION PROTOCOL PROCESSING SECTION
540
550
SIGNALING PROCESSING SECTION
USER DATA PROCESSING SECTION
630
IP TRANSPORT PROCESSING SECTION
570
L4 PROCESSING SECTION
AUTHENTICATION PROCESSING SECTION
640
610
580
IPSEC PROCESSING SECTION
620
ESP SA INFORMATION
IP PROCESSING SECTION
520
L2 PROCESSING SECTION
600
ETHERNET PROCESSING SECTION
500
510
LAN SIDE IF
RADIO SIDE IF

FIG.20

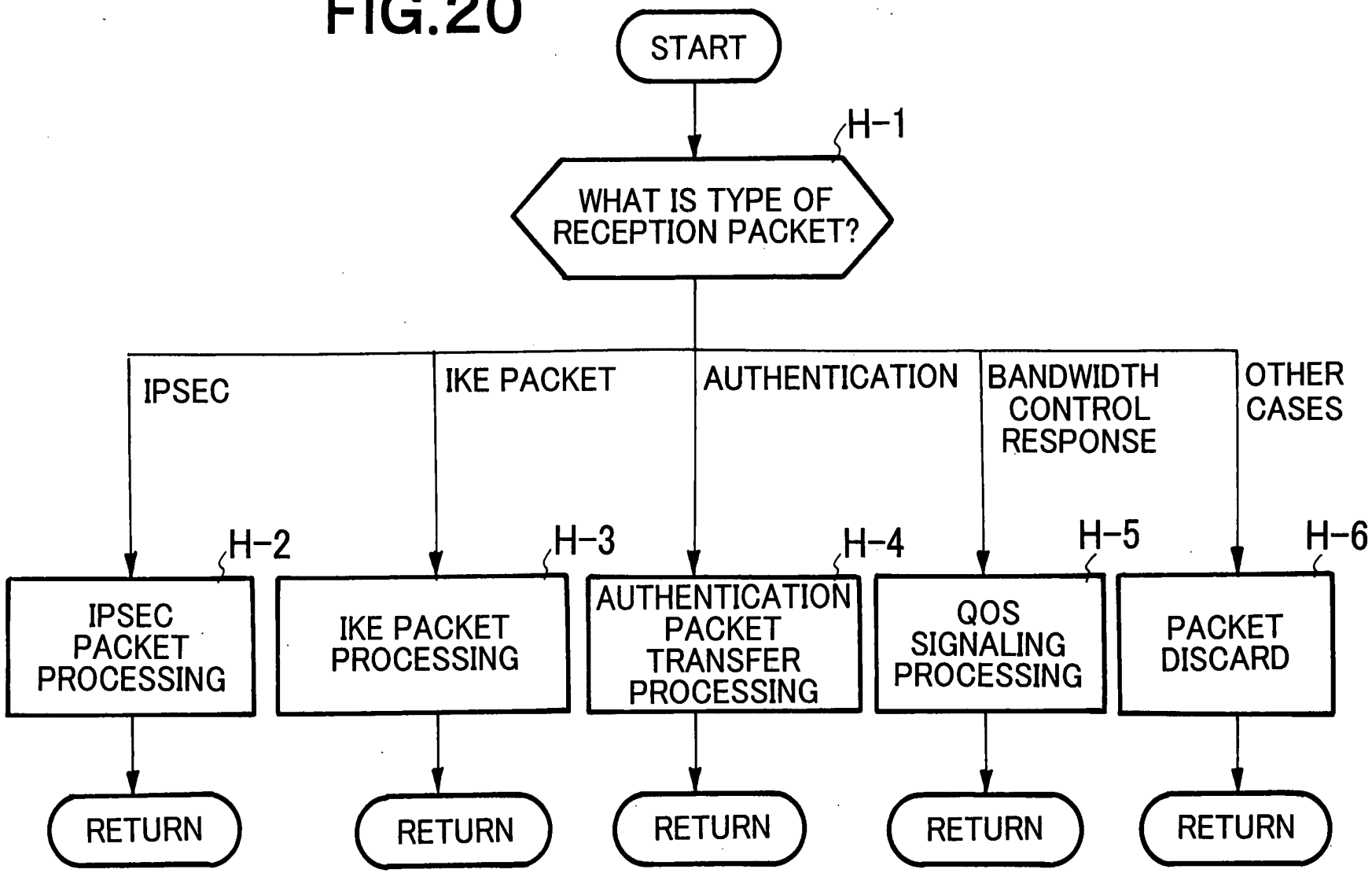

START
H-1
WHAT IS TYPE OF RECEPTION PACKET?
IPSEC
IKE PACKET
AUTHENTICATION
BANDWIDTH CONTROL RESPONSE
OTHER CASES
H-2
H-3
H-4
H-5
H-6
IPSEC PACKET PROCESSING
IKE PACKET PROCESSING
AUTHENTICATION PACKET TRANSFER PROCESSING
QOS SIGNALING PROCESSING
PACKET DISCARD
RETURN
RETURN
RETURN
RETURN
RETURN

FIG.21

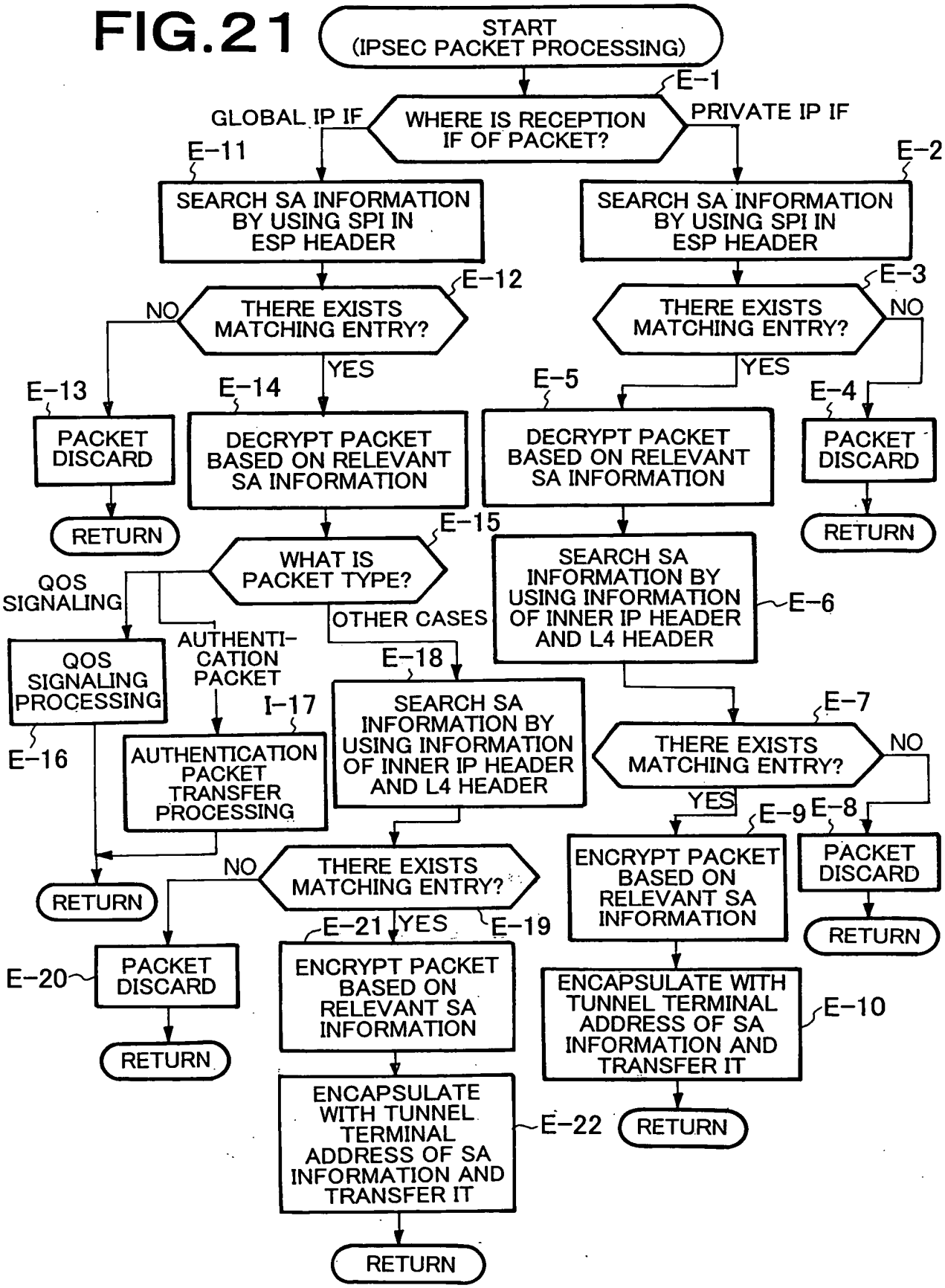

START
(IPSEC PACKET PROCESSING)
E-1
WHERE IS RECEPTION IF OF PACKET?
GLOBAL IP IF
PRIVATE IP IF
E-11
SEARCH SA INFORMATION BY USING SPI IN ESP HEADER
E-2
SEARCH SA INFORMATION BY USING SPI IN ESP HEADER
E-12
THERE EXISTS MATCHING ENTRY?
NO
YES
E-3
THERE EXISTS MATCHING ENTRY?
NO
YES
E-13
PACKET DISCARD
RETURN
E-14
DECRYPT PACKET BASED ON RELEVANT SA INFORMATION
E-5
DECRYPT PACKET BASED ON RELEVANT SA INFORMATION
E-4
PACKET DISCARD
RETURN
E-15
WHAT IS PACKET TYPE?
QOS SIGNALING
AUTHENTI-CATION PACKET
OTHER CASES
QOS SIGNALING PROCESSING
E-16
I-17
AUTHENTICATION PACKET TRANSFER PROCESSING
E-18
SEARCH SA INFORMATION BY USING INFORMATION OF INNER IP HEADER AND L4 HEADER
SEARCH SA INFORMATION BY USING INFORMATION OF INNER IP HEADER AND L4 HEADER
E-6
E-7
THERE EXISTS MATCHING ENTRY?
NO
YES
E-9
E-8
ENCRYPT PACKET BASED ON RELEVANT SA INFORMATION
PACKET DISCARD
RETURN
RETURN
NO
THERE EXISTS MATCHING ENTRY?
E-21
YES
E-19
E-20
PACKET DISCARD
RETURN
ENCRYPT PACKET BASED ON RELEVANT SA INFORMATION
ENCAPSULATE WITH TUNNEL TERMINAL ADDRESS OF SA INFORMATION AND TRANSFER IT
E-10
RETURN
ENCAPSULATE WITH TUNNEL TERMINAL ADDRESS OF SA INFORMATION AND TRANSFER IT
E-22
RETURN

FIG.22

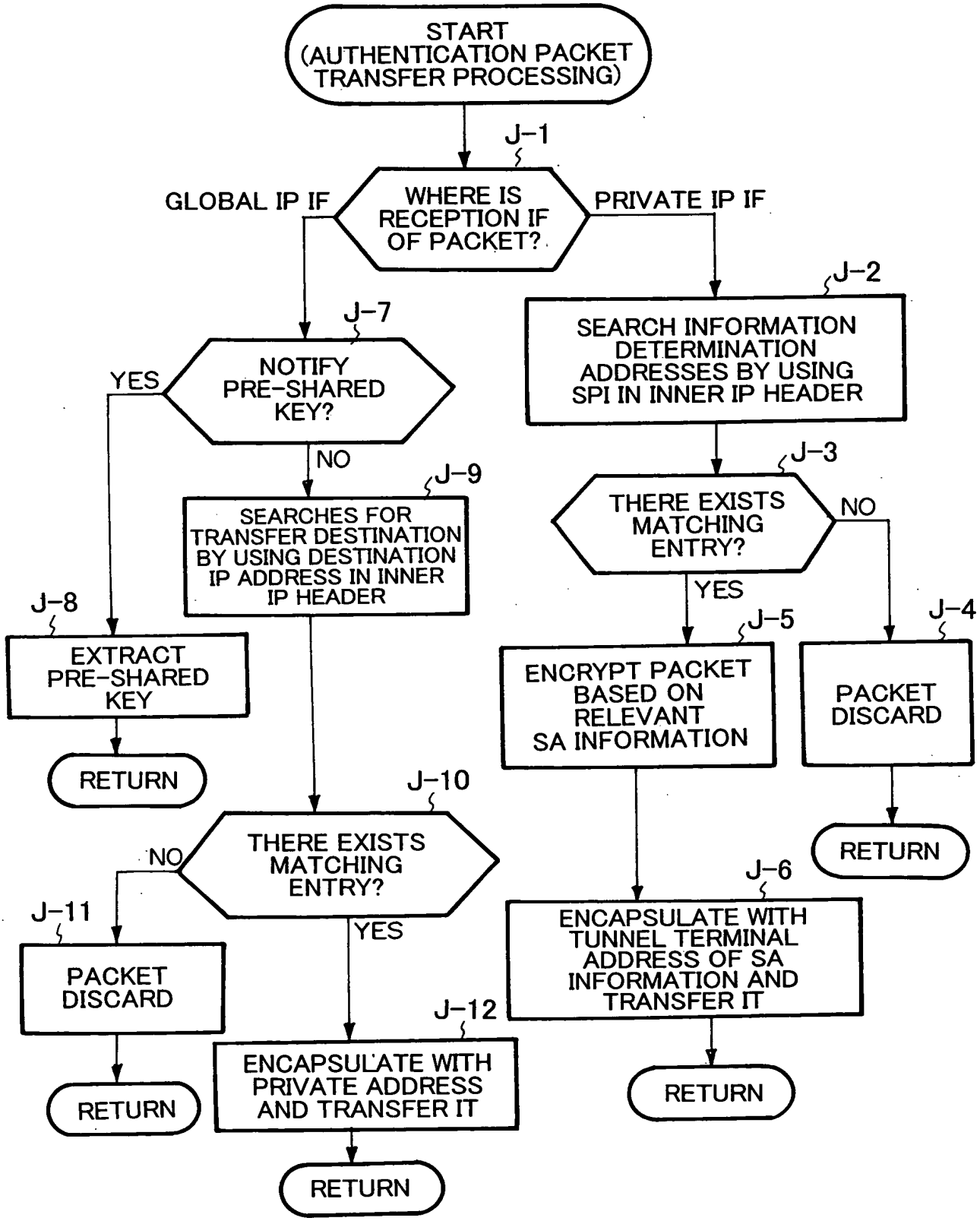

START (AUTHENTICATION PACKET TRANSFER PROCESSING)
J-1
WHERE IS RECEPTION IF OF PACKET?
GLOBAL IP IF
PRIVATE IP IF
J-2
SEARCH INFORMATION DETERMINATION ADDRESSES BY USING SPI IN INNER IP HEADER
J-3
THERE EXISTS MATCHING ENTRY?
NO
YES
J-4
PACKET DISCARD
RETURN
J-5
ENCRYPT PACKET BASED ON RELEVANT SA INFORMATION
J-6
ENCAPSULATE WITH TUNNEL TERMINAL ADDRESS OF SA INFORMATION AND TRANSFER IT
RETURN
J-7
NOTIFY PRE-SHARED KEY?
YES
NO
J-8
EXTRACT PRE-SHARED KEY
RETURN
J-9
SEARCHES FOR TRANSFER DESTINATION BY USING DESTINATION IP ADDRESS IN INNER IP HEADER
J-10
THERE EXISTS MATCHING ENTRY?
NO
YES
J-11
PACKET DISCARD
RETURN
J-12
ENCAPSULATE WITH PRIVATE ADDRESS AND TRANSFER IT
RETURN

FIG.23

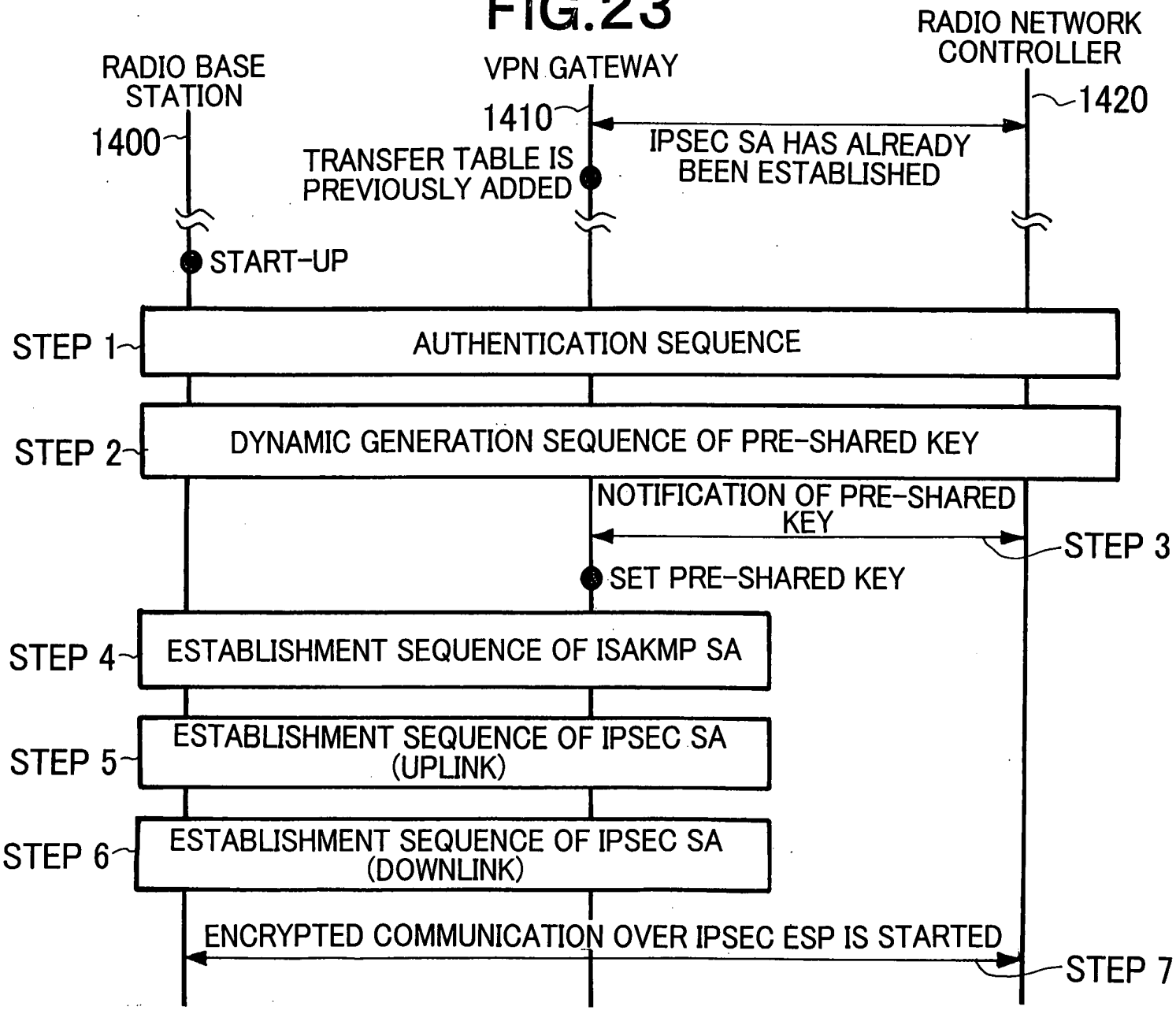
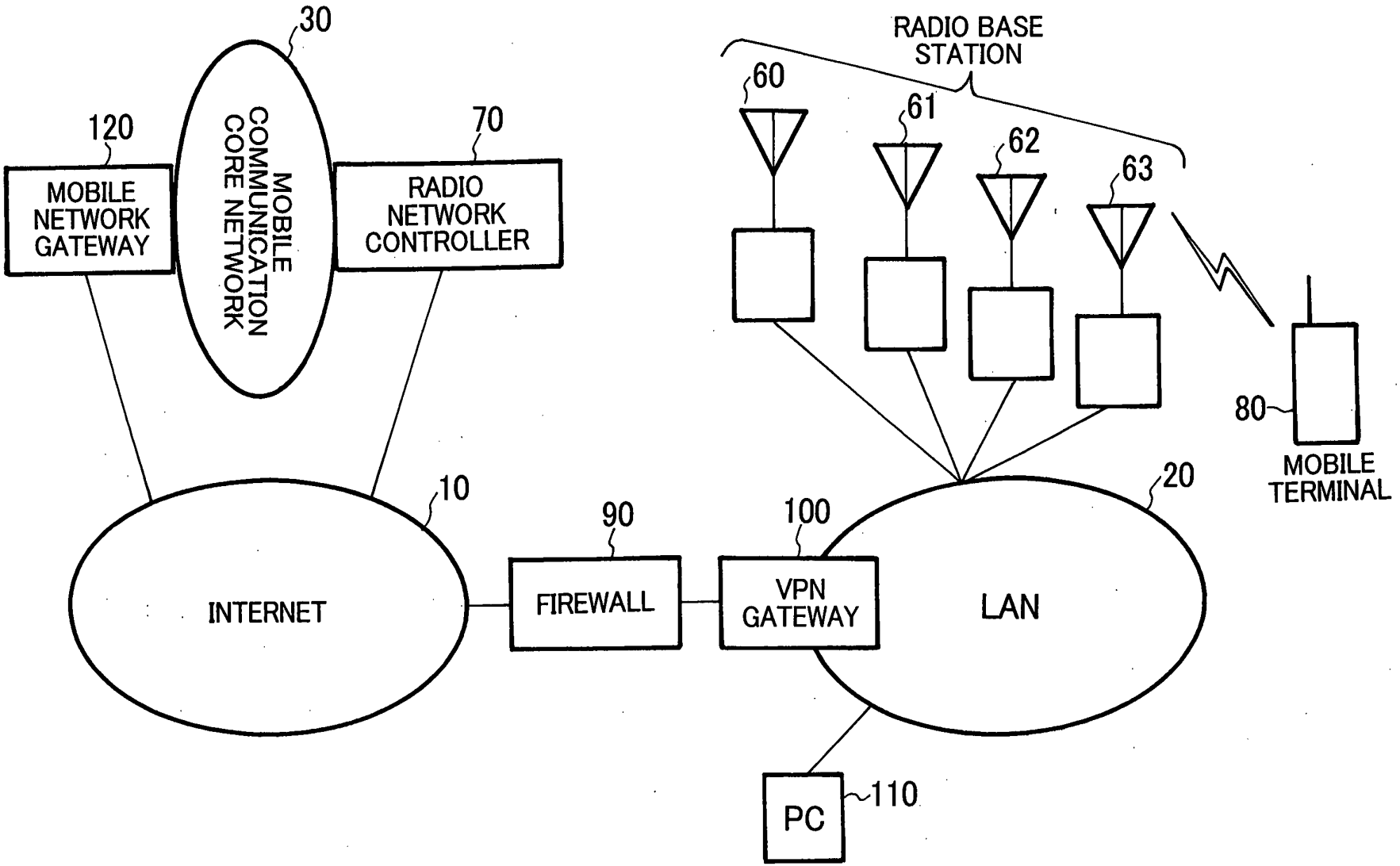

RADIO BASE STATION
1400
VPN GATEWAY
1410
RADIO NETWORK CONTROLLER
1420
TRANSFER TABLE IS PREVIOUSLY ADDED
IPSEC SA HAS ALREADY BEEN ESTABLISHED
START-UP
STEP 1
AUTHENTICATION SEQUENCE
STEP 2
DYNAMIC GENERATION SEQUENCE OF PRE-SHARED KEY
NOTIFICATION OF PRE-SHARED KEY
STEP 3
SET PRE-SHARED KEY
STEP 4
ESTABLISHMENT SEQUENCE OF ISAKMP SA
STEP 5
ESTABLISHMENT SEQUENCE OF IPSEC SA (UPLINK)
STEP 6
ESTABLISHMENT SEQUENCE OF IPSEC SA (DOWNLINK)
ENCRYPTED COMMUNICATION OVER IPSEC ESP IS STARTED
STEP 7

FIG.24


30
MOBILE COMMUNICATION CORE NETWORK
120
MOBILE NETWORK GATEWAY
70
RADIO NETWORK CONTROLLER
RADIO BASE STATION
60
61
62
63
80
MOBILE TERMINAL
10
INTERNET
90
FIREWALL
100
VPN GATEWAY
20
LAN
PC
110